IV. Forest Conditions, Health, and Productivity

This document provides forest management guidance that will be incorporated into future land management plans for state-owned properties in the five Berkshire Ecoregions. Accordingly, data on both past and current forest conditions will be presented so that those management plans can be developed in an appropriate context. First, a summary of the historical trends in, and impacts to, local forestland will be presented.

Historical Trends in Forest Composition

Assessment of current forest conditions, and determination of desired future condition are best accomplished with a thorough knowledge of past forest dynamics. An understanding of the background rates and causes of change in forested landscapes can help to guide conservation efforts on many scales (DeGraaf and Miller, 1996). Fortunately, early studies of forest composition in Southern New England prior to the time of European settlement do exist (Bromley, 1935; Cline and Spur, 1942; Braun, 1950), and these early studies have been augmented by recent, detailed historical research on forest dynamics (e.g., Foster et al., 1998; Fuller et al., 1998; Cogbill et al., 2002; Parshall and Foster, 2002; Hall et al., 2002; Foster et al., 2002; Bellemare et al., 2002; Gerhardt and Foster, 2002).

Forest ecosystem structure, composition, and function are strongly conditioned by history, and modern conservation strategies must be based on an understanding of processes and events often occurring in the distant past (Foster et al., 2002). Forest ecosystems are dynamic as a consequence of disturbance and environmental change, and many biological processes unfold over century-long periods. These dynamics establish legacies in soils or ecosystem structure and composition that may endure for decades or centuries (Foster et al., 2002).

At the time of European settlement, the distribution of tree taxa and forest assemblages across Massachusetts showed pronounced regional variation, and corresponded strongly to climate gradients. The dominance of northern hardwoods and hemlock in the cooler uplands and oak and hickory at lower elevations is consistent with the regional distribution of these taxa and suggests a strong climatic control over broad-scale vegetation patterns (Foster et al., 1998). Vegetation in the cooler uplands of Massachusetts was a continuous geographical sequence typified primarily by beech among the northern hardwoods, while forests at lower elevations were typified by various species of oak (Cogbill et al., 2002).

Spatial, vegetational, and environmental patterns across Massachusetts prior to European settlement demonstrate a distinct “tension zone” separating northern hardwood and central hardwood areas. The pre-European-settlement northern hardwood forest (dominated by beech) forms a continuum responding to a complex climatic gradient of altitude and latitude. The oak forests to the south are distinguished by non-zonal units, probably affected by fire (Cogbill et al., 2002).

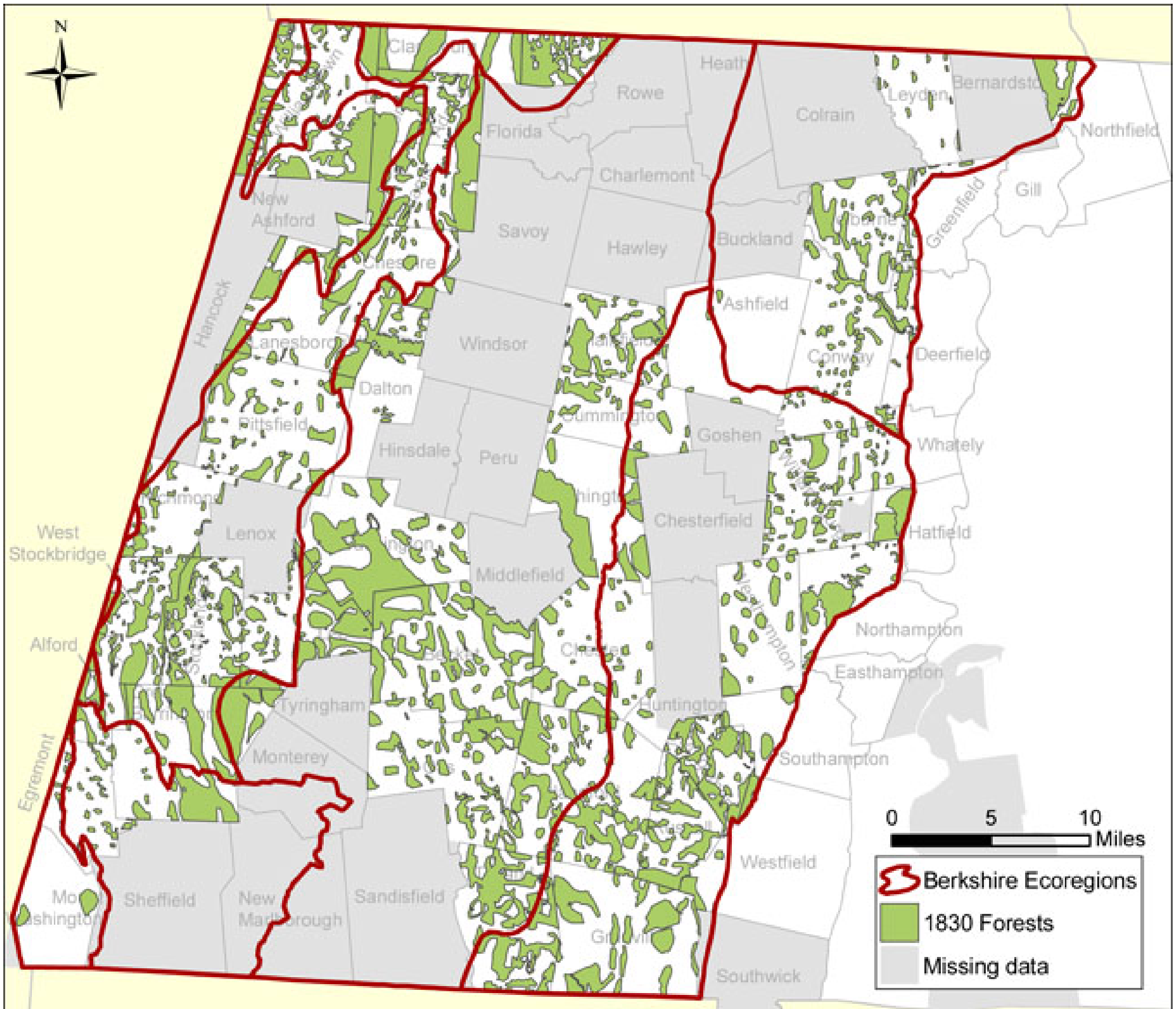
Based on historical and paleoecological data, it is unclear how extensive natural or aboriginal disturbance was in the Uplands (Parshall and Foster, 2002), whereas infrequent surface fires in the Lowlands may have helped to maintain the abundance of central hardwoods and to restrict the abundance of hemlock, beech, and sugar maple in these areas (Foster et al., 1998; Fuller et al., 1998; Parshall and Foster, 2002). It appears that the pre-settlement forest across Massachusetts did not contain as much white pine, hemlock and chestnut as previously thought (although each of these species was at times locally abundant), and that the tension zone between northern hardwood and central hardwood (mixed oak) forest was more distinct than previously thought (Cogbill et al., 2002). The regional occurrence of white pine apparently increased following European settlement, (Parshall and Foster, 2002).

It is widely accepted today that the post-European settlement view of forests as commodities to be exploited led to a dramatic and drastic alteration of the forest landscape throughout Massachusetts during the 18th and 19th centuries (Foster et al., 1998). Past human disturbance (e.g., agricultural conversion and/or cutting), as well as human control of natural disturbance (most notably fire), have greatly modified overstory tree species composition on many sites (Foster et al., 1998 and Abrams, 1999). These alterations have obscured the regional forest patterns that corresponded to climate, substrate, and fire regime (Foster et al., 1998 and Fuller et al., 1998). Modern vegetation is compositionally distinct from Colonial vegetation, exhibits less regional variation in the distribution of tree taxa or forest assemblages defined by tree taxa, and show little relationship to broad climatic gradients. Among the most notable changes are a massive increase in red maple and birch in the southern portion of the Central Uplands (Foster et al., 1998).

Around the height of agricultural clearing in 1830, much of the Berkshire Ecoregions had been converted from forest to field. 45 communities in the Berkshire Ecoregions have 1830s forest data. (**Figure 19 and Table 9)**. Just under 37% of the land was in forest (or 63% open) within these 45 communities, primarily due to agricultural abandonment in the late 19th and early 20th century. The Berkshire Ecoregions are today mostly in forest cover (~80%). Within the Berkshire Ecoregions, modern forest vegetation is dissimilar to pre-settlement forests in terms of composition, inferred structure, and relationship to regional environmental gradients despite the extensive process of natural reforestation and forest maturation that has occurred over the past 100-150 years. Whereas forest vegetation per se has proven to be highly resilient to the human impacts and natural changes that have occurred during historical times, individual taxa have responded in highly variable ways to produce landscape patterns that contrast strongly with those of the colonial period (Foster et al., 1998).

While it is important to consider pre-settlement forest condition, it is equally important to remember that forest condition was not static prior to European settlement of Massachusetts (Fuller et al., 1998). Paleoecological studies have documented that species composition has shifted over the millennia within the general northern hardwood and oak forest types that originally dominated what is now Massachusetts (Foster et al., 2002). Accordingly, there is no "ideal" or "original" forest composition to manage for today. Change is the norm in temperate forest landscapes, and management today occurs within a varied historical context.

While tree species composition of Massachusetts forestland can be expected to vary widely, forest managers can realize many, if not all, of the habitat benefits associated with structural attributes of unmanaged forest landscapes by incorporating natural structural patterns into managed forestland (Spur and Cline, 1942;, Franklin and Forman, 1987; Hansen et al., 1991; Rowe, 1992; Aplet et al., 1993; DeGraaf and Healy, 1993; Franklin, 1993;, Mladenoff and Pastor, 1993; Mladenoff et al., 1993; Noss, 1993; Alverson et al., 1994; Lorimer and Frelich, 1994; deMayndier and Hunter, 1995; Meier et al., 1995; Yahner, 1995; Hunter, 1996b; Rogers, 1996; Lindenmayer and Franklin, 1997; Foster and Foster, 1999; Seymour and Hunter, 1999). Forest cutting practices that incorporate structural patterns associated with natural disturbance processes will help sustain the long-term productive potential of forests, maintain biodiversity, and provide a buffer against future uncertainties such as climate change (Mladenoff and Pastor, 1993), natural disturbance (e.g., wind, fire, and insect infestations) (Foster and Foster, 1999), and economic shifts in market conditions.



Hall, B., G. Motzkin, D. R. Foster, M. Syfert, and J. Burk. 2002. Three hundred years of forest and land-use change in Massachusetts, USA. Journal of Biogeography 129: 1319-1135.

Figure 19. 1830 Forest (Berkshire Ecoregions)

Table 9. 1830 Forest (Berkshire Ecoregions) Data from Figure 19.

Ecoregion / Land Type Association	Total acres in ecoregion	Total 1830 acres in ecoregion *	Total acres of forest in 1830*	% of the ecoregion in forest in 1830*
Hudson Highlands Ecoregion	**304,920**	**203,106**	**61,994**	*30.5%*
Berkshire Transition Association	*229,616*	*179,725*	*55,665*	*31.0%*
Western New England Marble Valley Association	*75,304*	*23,382*	*6,329*	*27.1%*
Taconic Mountains Ecoregion	**236,068**	**189,568**	**78,246**	***41.3%***
Taconic Highlands Association	*81,519*	*50,526*	*27,191*	*53.8%*
Western New England Marble Valley Association	*154,549*	*139,042*	*51,055*	*36.7%*
Berkshire-Vermont Upland Ecoregion	**433,948**	**200,445**	**81,801**	**40.8%**
Southern Green Mountains Ecoregion	**20,500**	**17,993**	**9,617**	**53.4%**
Southern Vermont Piedmont Ecoregion	**138,574**	**75,386**	**12,782**	**17.0%**
TOTALS	**1,370,079**	**876,066**	**322,688**	**36.8%**

* This estimate applies to only those communities (45) in the Berkshire Ecoregions for which there was 1830s forest data.

Current Forest Conditions

The USDA Forest Service conducts periodic assessments of forest conditions under its Forest Inventory and Analysis (FIA) program (***http://fia.fs.fed.us/***). Massachusetts is in the Northeastern Region of the USDA Forest Service (***www.fs.fed.us/ne/fia/index.html***). The FIA assessments for Massachusetts were most recently been completed in 1984 and in 1998. The 1998 FIA analysis was conducted using data from 798 plots. Some of the results from the FIA data for the Berkshire Ecoregions is presented below. It should be noted however that the FIA data is based on surveys of a limited number of plots. Each plot represents ~6,000 acres and when data is summarized for smaller units (e.g., an ecoregion versus the state as a whole), the accuracy of the estimate declines. Thus, while the data presented here paints a useful picture of the general forest conditions in the Berkshire Ecoregions, appropriate caution should be used in interpreting what is presented here. Further details on the "Methodology" of FIA is available at (***www.fs.fed.us/ne/fia/methodology/index.html***).

The FIA data supports the MassGIS-based estimates (presented earlier) that the Berkshire Ecoregions are a largely forested area. However, FIA estimates indicate that the Berkshire Ecoregions are 84.7% forested (vs. 62% statewide). This is a 5.6 % difference from the MassGIS data (79.09%) presented earlier in **Table 3**. Discrepancies in the data have been discussed with the USDA / FIA staff, and are currently under review (see **Appendix X**).

Over 68%of the total forested acreage of the Berkshire Ecoregions is in the Maple/Beech/Birch forest type (**Table 10**). Almost 80% of the 35,242 acres of seedling/sapling forest in the Berkshire Ecoregions consists of maple/beech/birch (28,135 acres) type.

When growing stock volumes are analyzed by diameter class, several trends are evident (**Figures 15 and 20**). [INSERT CORRECTED DATA FROM USDA FS when available}

Table 10. Timberland area by forest-type group and size class (Berkshire Ecoregions).

Forest type	Sawtimber	Poletimber	Seeding/ sapling	Total	% of Total
White/Red/Jack Pine	179,406	3,861	2,164	185,431	20.1%
Spruce/Fir	0	1,533	0	1,533	0.2%
Oak/Pine	21,575	1,164	0	22,738	2.5%
Oak/Hickory	47,535	11,122	0	58,656	6.3%
Elm/Ash/Cottonwood	0	0	1,752	1,752	0.2%
Maple/Beech/Birch	422,253	179,548	28,135	629,935	68.2%
Aspen/Birch	14,404	6,224	3,191	23,819	2.6%
Totals	685,173	203,452	35,242	923,864	100.0%
Percent	74.2%	22.0%	3.8%		

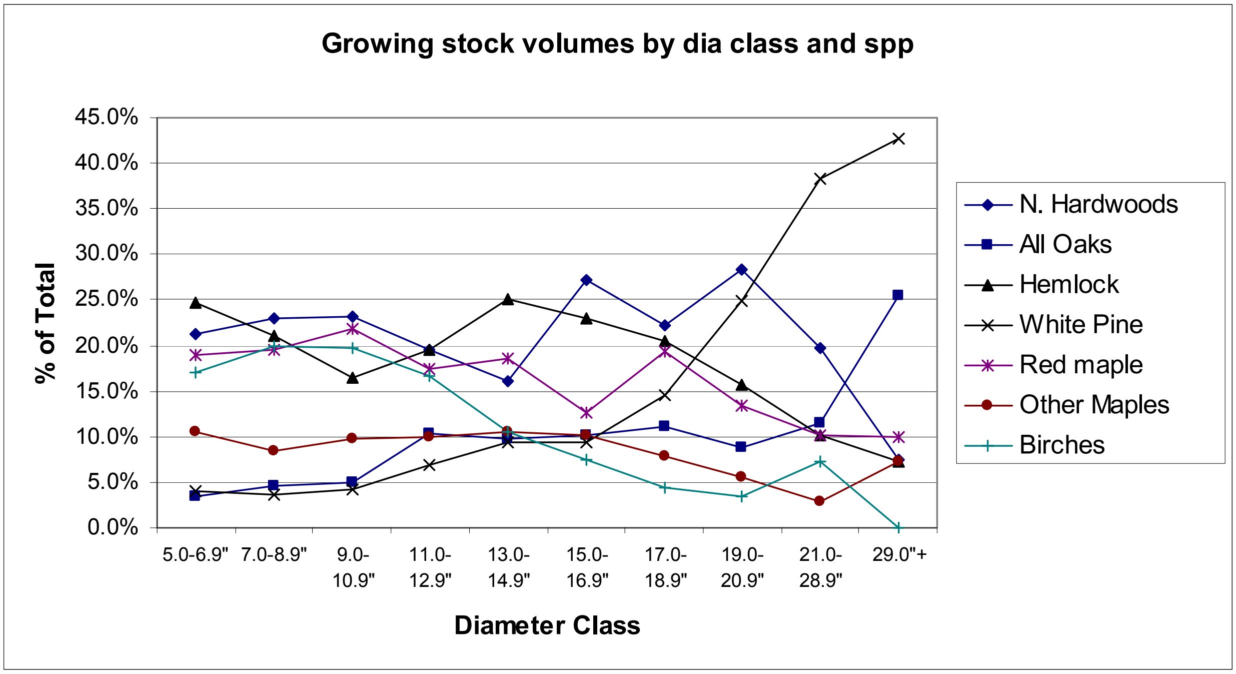


Figure 20. Growing stock volumes by diameter class for selected species in the Berkshire Ecoregions.

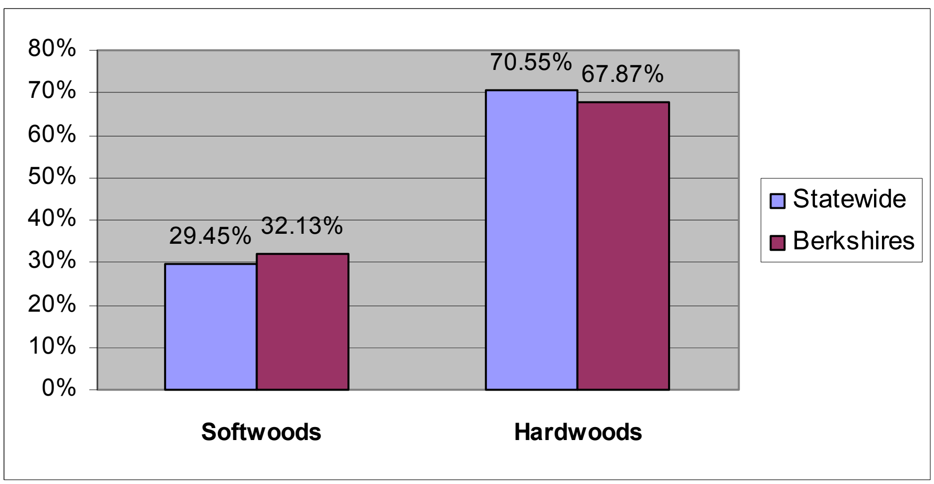


Figure 21. Hardwoods and softwoods as percentages of live trees in the Berkshire Ecoregions and statewide.

Table 11. [INSERT when corrected USDA FS FIA data is available]
Average annual growth stock and removal of sawtimber volume (in Board feet) in the Berkshire Ecoregions and Statewide, 1984 - 1998

Forest Disturbance Agents

Disturbance is a natural – even necessary - process in forest ecosystems. In addition to timber harvest activities, forests in these five (5) ecoregions are affected by a number of other disturbance agents, including storm events (wind, ice, etc.), insects, diseases, and others. The state Bureau of Forestry, through its Forest Health Program, generally monitors forest stress factors that might be causing declines in the forest resource. This is done with both aerial and ground-based surveys. As an example, from 1990 through 1997, these surveys documented almost 320 separate instances of forest decline on more than 101,763 acres in these five (5) ecoregions (**Table 12**). It should be noted however, that some of these were repeat damage in the same forest stands. By far, the major agent of this damage was the Gypsy Moth *(Lymantria dispar),* which accounted for more than 46% of the affected acreage.

Berkshire Ecoregions Status

Hemlock Wooley Adelgid, Hemlock Looper, and Elongate Hemlock Scale

There are three pests threatening the hemlock resource in the Berkshire Ecoregions; Hemlock Woolly Adelgid (*Adelges tsugae*), the fall flying Hemlock Looper (*Lambdina fiscellaria*), and the recent discovery of elongate hemlock scale (*Fiorinia externa*). Hemlock Woolly Adelgid was first identified in southern Berkshire County (Great Barrington) in 2001. Since that time it has spread and is now found in 5 south county communities. In 2003 two releases of *Sasajiscymnus tsugae* (formally *Pseudoscymnus tsugae*) a predatory ladybird beetle have been conducted. At one of these release sites we feel this predator has become established, at the second site we have been unable to make recoveries. Hemlock looper, a native caterpillar is always present in low densities throughout the ecoregions. On two occasions it has entered outbreak phase requiring the aerial application of a biological insecticide to limited acreage in the Tolland and Otis State forests. In 2004 the annual aerial survey detected ?? acres of hemlock decline. Follow-up ground surveys of this area resulted in the discovery of the elongate hemlock scale as the primary cause of this decline. This is the first record of this insect causing widespread decline and mortality in Massachusetts.
http://www.na.fs.fed.us/fhp/hwa/
http://www.na.fs.fed.us/spfo/pubs/pest_al/hem-looper/hem-looper.htm
http://www.na.fs.fed.us/pubs/palerts/EHScale.pdf

Beech Bark Disease

Beech Bark Disease is widespread throughout the Berkshire Ecoregions and continues to cause mortality. This mortality is more prevalent on the higher elevation, drier sites. As the mature beech decline they tend to produce prolific root sprouts. These sprouts develop into very dense thickets which hinder the development of desired regeneration.
www.na.fs.fed.us/fhp/bbd/

Ash Decline

Over an extended period of time much of the white ash growing on poorer sites has experienced decline and mortality. This can be attributed to prior drought conditions, predisposing these trees to attack from secondary organisms such as ash borer and various root diseases such as *Armillaria*. Previously much of this decline as attributed to Ash Yellows; however as a result of a recent training it is now believed that ash yellows is not a contributing factor.

Sugar Maple Decline

In the early 80's many agencies expressed concern for the health of the sugar maple resource. As a result of these concerns a joint United States and Canadian research project, the North American Maple Project was developed. This project was designed to evaluate the many stress factors affecting this resource such as acid rain and to compare managed sugar bushes and non managed forest stands. The outcome of this project indicated that there was little difference in tree health between the managed and unmanaged stands. It also highlighted the fact that acid rain in certain locations was affecting the forest heath, but this greatly depended on the elevation, soil types and its ability of the soils to buffer the effects of the acid deposition. During the period of this study the sugar maple suffered heavy defoliation by pear thrips. This insect is an early season defoliator which severely weakened the trees thus making them more susceptible to attack by the sugar maple borer. The North American Maple Project did not study the roadside trees but observations indicate that these trees are in a severe state of decline because of many environmental factors such as road salt, poor growing conditions and lack of maintenance.
http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/scanned/gtr154.pdf
http://ncrs.fs.fed.us/pubs/viewpub.asp?key=1738&cart=1

Forest Tent Caterpillar

The 2004 aerial survey documented several areas of defoliation in Central Berkshire County caused by Forest Tent Caterpillar (*Malacosoma disstria* Hubner). There are no records of this insect causing widespread defoliation in the Berkshire County prior to this year. It is believed that parasites released for the control of gypsy moth also were responsible for keeping forest tent caterpillars in check. With gypsy moth populations currently being controlled by Entomophaga there has been only a limited number of hosts to sustain these parasite populations.
www.na.fs.fed.us/spfo/pubs/pest_al/ftc/ftc.htm

Sudden Oak Death (SOD)

Sudden Oak Death (*Phytophthora ramorum*), also know as ramorum leaf blight and ramorum dieback, has not been confirmed in New England. If this pathogen is detected the most likely source of introduction will be from the importation of infected nursery stock. Recently enacted regulations have placed severe restriction on the shipment of susceptible nursery stock from infected states. A risk assessment completed by the USDA Forest Service indicates that the Berkshire Ecoregion is not highly susceptible to sudden oak death because of the lack of proper climatic conditions at the time of year when infection must take place. Early detection is the key to protecting the oak resource. To accomplish this surveys for this disease are on going so any possible introductions can be detected and eradicated before is spreads to the natural environment.
www.aphis.usda.gov/ppq/ispm/pramorum/
fhm.fs.fed.us/sp/sod/sod.shtm

Emerald Ash Borer and Asian Longhorned Beetle

There are several exotic wood boring beetles that pose a threat to the forest and shade tree resource in the Berkshire Ecoregion; Emerald Ash Borer (*Agrilus planipennis* Fairmaire) and Asian Longhorned Beetle (Anoplophora glabripennis) are the most serious threats. The most likely source of introduction of these pests is from receipt of infected nursery stock or forest products from infected areas. Should either of these insects be introduced to this area they have the potential to become established and could dramically alter the forest composition as we presently know it. For this reason intensive surveys are being conducted so that any introductions can be identified, isolated and eradicated.

www.na.fs.fed.us/fhp/eab/index.shtm
www.na.fs.fed.us/fhp/alb/

Hemlock Woolly Adelgid

Since its arrival in Massachusetts in the late 1980s, significant concern has been expressed about the present and potential future impacts of the hemlock woolly adelgid (HWA; *Adelges tsugae*). HWA has already devastated thousands of acres of hemlock in other parts of the northeast, and has recently spread throughout Massachusetts. Where hemlock comprises a major portion of forest stands, mortality rates can be very high. The USDA Forest Service website on HWA (***www.fs.fed.us/na/morgantown/fhp/hwa/)*** is an excellent starting point for understanding the biology and distribution of this pest, and provides links to many other related sites.

The hemlock woolly adelgid is a small aphid-like insect native to Japan. It arrived in North America in the 1920s, and was first recognized on the east coast of the US in 1951 and in Connecticut in 1985. It is gradually spreading in all directions across the range of eastern hemlock (*Tsuga canadensis)*. It is a serious pest on both eastern hemlock and Carolina hemlock (*Tsuga caroliniana* Engelm), but does not seriously injure the western hemlocks (*Tsuga heterophylla* or *Tsuga mertensiana*).

The hemlock woolly adelgid is a particularly troublesome pest for several reasons:

1. The insect is without natural enemies in the northeastern US. Several potential biocontrols have been imported from Japan and China, reared in laboratories, and released at HWA sites, but to date these have had very limited impact for a variety of reasons. Successful chemical controls are mostly limited to systemics and dormant oil spraying. These can be effective in ornamental plantings, but are virtually impossible to apply in an extensive forest infestation.
2. The HWA is parthenogenic, which means that every adult is capable of reproduction. Each adult lays 50-300 eggs, typically about 100. Furthermore, the population successfully completes two generations within a year. The first eggs are laid in March and April. Crawlers hatch from these eggs and begin feeding at the base of needles, where they remain throughout development. This generation matures in mid-June, when adults lay eggs again. These hatch in July, move to new hemlock growth and then become dormant until October, when they begin feeding again. They continue feeding throughout the winter (the species evolved in high elevations in Asia and tolerates low temperatures), maturing by spring to begin the process again.
3. While hemlocks that are under attack eventually become incapable of supporting the infestation, resulting in a population crash in the HWA on that tree, these trees are also incapable of recovering from this level of damage. Trees that are infected may die within 4-5 years, although some may persist for longer in a weakened condition. The insect attacks all ages of trees, and in fact prefers younger foliage. Research by Harvard Forest ecologists and others indicates there is so far no clear evidence of resistance sufficient to allow any individual eastern hemlock tree to survive once infested with the hemlock woolly adelgid.
4. Where hemlock dominates the riparian zone along streams, HWA mortality is of particular concern. Loss of this overstory may present short-term threats to water quality and the aquatic ecosystem by raising stream temperatures and through nitrogen losses following increases in nitrogen mineralization and nitrification rates. Regeneration of the riparian zone regulates nutrient losses to stream water and will eventually restore temperature regulation, although not to the extent formerly provided by dense, evergreen hemlock cover.
5. From a biological diversity perspective, the loss of hemlock-dominated habitats can have important effects on a variety of wildlife. The importance of this dense cover as winter habitat for large ungulates (moose, deer) has been well-documented. The black-throated green warbler, Blackburnian warbler, and Acadian flycatcher are all very strongly associated with dense hemlock forests. A variety of amphibians benefit from the cool, moist conditions associated with dense, dark hemlock forests.

Managers of state and private properties throughout the northeast are working to develop strategies to react to and regulate the effects of HWA. Practices that have been used to varying degrees of success include chemical and biological controls:

1. Chemical control uses insecticidal soaps and/or horticultural oils on foliage, or soil drenching or injection with imidacloprid. Due to cost and the difficulty of application, these controls are usually limited to small, accessible areas of particular value, generally in landscaped settings. Some organizations have considered using chemical controls to establish hemlock refugia, from which hemlock might repopulate the surrounding forest once the HWA infestation has passed through.
2. Biological control involves releasing known insect predators of the HWA, imported from Asia and reared in labs prior to release. Researchers have been experimenting with *Scymnus* and *Pseudoscymnus* lady beetles and the *Diapterobates humeralis* mite. In Massachusetts, one of the most closely-followed releases was in Hemlock Gorge, a 23-acre park along the Charles River, for which legislation was passed to fund the rearing and release of *Pseudoscymnus* beetles. 10,000 beetles were released in 2001 and their impact is yet to be thoroughly documented. There has been some concern about the unintended ecological effects of releasing imported biocontrols, so research continues on both the direct effects on HWA and the potential impacts on native invertebrates. In addition to insect predators, research is underway to try to discover fungi that may reduce HWA success.

Given the likelihood of severe losses in hemlock stands, land managers have also responded with extensive salvage cutting. Some of this is initiated after infestations are apparent, while some is done in anticipation of infestations, usually in order to take advantage of market opportunities or to avoid price declines associated with market surpluses in a region badly infected with HWA. Research at Harvard Forest indicates that heavy cutting of stands that were not yet infected results in significantly greater decomposition of organics and accumulations of inorganic nutrients in soil water than in stands that gradually died and regenerated. These effects are likely short-term and there is not yet direct evidence that the pooled nutrients find there way to adjacent surface waters. Regeneration of these cut stands will reincorporate released nutrients through biomass accumulation.

There are many ecological factors to consider in making decisions regarding hemlock salvage. There is wide variety in the longevity of individual trees following HWA infestation, and some trees seem to persist for a long time with no sign of having become infected. If there is genotypic resistance to HWA, salvage harvesting in advance of an infestation runs the risk of removing trees that may have survived or at least persisted for a long time. A decision to try to replace hemlock by cutting and planting to a species with similar characteristics is problematic. Hemlock is the only native Massachusetts tree species that produces dense, shade-tolerant foliage with deep, acidic duff layers and cool, moist, depauperate understories. Non-native plantings such as Norway spruce may imitate hemlock stand conditions, but it appears likely that most hemlock stands in Massachusetts will naturally regenerate to a mix of native species, predominantly black birch, following either salvage cutting or HWA mortality.

Table 12. Forest Damage Agents in the Berkshire Ecoregions (1990-1997).

Agent or observation	Count	Acres	% of Total
Ash decline/yellow	1	114	0.11%
Beech Bark Disease	25	6,327	6.22%
Beech Mortality	2	431	0.42%
Beech/Maple	4	1,668	1.64%
Cherry Scallop Shell Moth	22	7,384	7.26%
Chestnut Blight	1	112	0.11%
Dead Hemlock	1	128	0.13%
Dead Trees	2	1,241	1.22%
Drought	27	4,424	4.35%
Drought (Beech)	1	134	0.13%
Fire	2	143	0.14%
Gypsy Moth	67	47,004	46.19%
Gypsy Moth - Heavy Mortality	6	1,403	1.38%
Gypsy Moth-Light	3	1,431	1.41%
Gypsy Moth-Moderate	1	13	0.01%
Hemlock Looper	18	1,942	1.91%
Logging	8	1,478	1.45%
Logging (New Growth)	3	715	0.70%
Off Color (Brown) Pine	38	7,920	7.78%
Red Spruce Winter Injury	11	1,502	1.48%
Red White Spruce	1	334	0.33%
Saddled Prominent	4	343	0.34%
Snow-ice	3	193	0.19%
Spruce Gall Adelgid	3	283	0.28%
Storm Damage	16	2,769	2.72%
Unknown	43	11,619	11.42%
Wild-fire	1	101	0.10%
Wind-tornado	6	607	0.60%
Total:	**320**	**101,763**	**100.00%**

Source: DCR / MassGIS